The Pulsed Fission-Fusion (PuFF) Concept for Deep Space Exploration and Terrestrial Power Generation

Robert Adams[1], Jason Cassibry[2], Kevin Schillo[2]

[1] *National Aeronautics and Space Administration, MSFC, AL, USA*
[2] *University of Alabama in Huntsville, Huntsville, AL, USA*

Abstract: This team is exploring a modified Z-pinch geometry as a propulsion system, imploding a liner of liquid lithium onto a pellet containing both fission and fusion fuel. The plasma resulting from the fission and fusion burn expands against a magnetic nozzle, for propulsion, or a magnetic confinement system, for terrestrial power generation.

There is considerable synergy in the concept; the lithium acts as a temporary virtual cathode, and adds reaction mass for propulsion. Further, the lithium acts as a radiation shield against generated neutrons and gamma rays. Finally, the density profile of the column can be tailored using the lithium sheath. Recent theoretical and experimental developments (e.g. tailored density profile in the fuel injection, shear stabilization, and magnetic shear stabilization) have had great success in mitigating instabilities that have plagued previous fusion efforts.

This paper will review the work in evaluating the pellet sizes and z-pinch conditions for optimal PuFF propulsion. Trades of pellet size and composition with z-pinch power levels and conditions for the tamper and lithium implosion are evaluated.

Current models, both theoretical and computational, show that a z-pinch can ignite a small (~1 cm radius) fission-fusion target with significant yield. Comparison is made between pure fission and boosted fission targets. Performance is shown for crewed spacecraft for high speed Mars round trip missions and near interstellar robotic missions.

The PuFF concept also offers a solution for terrestrial power production. PuFF can, with recycling of the effluent, achieve near 100% burnup of fission fuel, providing a very attractive power source with minimal waste. The small size of PuFF relative to today's plants enables a more distributed power network and less exposure to natural or man-made disruptions.

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